In Situ Observation of Irradiance- and Time-Dependent Changes in Phytoplankton Absorption Coefficients

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LONG-TERM GOAL

My long-term goals are to understand the causes of and mechanisms responsible for variability in phytoplankton abundance, primary production, and species composition. A continuing objective of my research has been to determine phytoplankton absorption coefficients and to ask why and how they change. My rationale is that if we understand why and how these coefficients change, we can better predict changes in water column optics, as well as invert in-water and remotely-sensed optical signals to extract information about water-column optics and phytoplankton themselves.

OBJECTIVES

There were two primary objectives of this project. One was to extend the laboratory-bench method for determining the phytoplankton photosynthetic absorption coefficients to in-water measurements. The second was to determine the role of in-situ photosynthesis and growth in the development and maintenance of phytoplankton thin layers in East Sound, Washington.

APPROACH

Phytoplankton absorption is a major determinant of the optical properties of coastal waters. However, the large variability in the spectral shape of the phytoplankton absorption coefficient is a major contributor to the errors in inverse models for extracting phytoplankton coefficients from hyperspectral in-water or remotely-sensed measurements. This variability in spectral shape among different water masses, and even within the same water mass under different environmental conditions, is a result of the bipartite nature of the phytoplankton absorption coefficient. The coefficient has two components: a photosynthetic absorption coefficient and a photoprotective absorption coefficient. Unless the two components can be objectively and independently analyzed, it is difficult to constrain or predict the variance in the total absorption coefficient. For discrete water samples, it is possible to distinguish these two coefficients by combining spectral excitation-emission fluorometry with phytoplankton absorption coefficient measurements. Our approach in this project is to extend this method to in-water measurements with a SAFIRE (the multi-spectral, in-water, excitation-emission fluorometer manufactured by WET Labs).

The approach taken to meet the second objective, i.e., the role of in-situ photosynthesis and growth in the development and maintenance of phytoplankton thin layers in East Sound, was to measure photosynthesis as a function of irradiance and predict the contribution of in-situ growth to thin layer dynamics.

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WORK COMPLETED

A successful three-week cruise was made in June 1998 in East Sound, Orcas Island, Washington, as part of the Thin Layers Program. The SAFIRE was deployed on multiple profiles, in conjunction with Dr. Cowles' (OSU) the optical profiler. Photosynthesis vs. irradiance measurements were made for waters sampled from within thin layers and from outside layers. Additional measurements were taken for chlorophyll *a*, nutrients (nitrate, nitrate, ammonium, silicate, and phosphate), absorption coefficients (particulate, detrital, and phytoplankton), and phytoplankton species composition.

RESULTS

The photosynthesis vs. irradiance measurements, chlorophyll *a* and nutrient samples have been analyzed. Phytoplankton biomass was variable, and occasionally high. On some days nutrient concentrations were close to the limit of detection with standard autoanalyzer methods. The samples for absorption coefficients are in the process of being analyzed. When these measurements have been completed, we will used them to model primary production in the layers. Data from the East Sound deployment of the SAFIRE are being analyzed. Final interpretation of the SAFIRE data set is pending characterization of the excitation and emission filters, scattering correction, and temperature response.

IMPACTS

The ability to measure photosynthetic absorption coefficients in situ will allow us to better examine the statics and dynamics of the changes in the subcomponents of the phytoplankton spectral absorption coefficient as a function of the major environmental forcings, specifically irradiance and mixing. The role of in situ photosynthesis and growth of phytoplankton within thin layers will allow us to better understand the role of biology vs. physics in the maintenance of thin layers of phytoplankton.

TRANSITIONS

None at this time.

RELATED PROJECTS

I collaborated with the following ONR-funded PIs as part of the Thin Layers Program in East Sound in June 1998: Dr. Percy Donaghay and Dr. Dian Gifford, URI; Dr. Timothy Cowles and Dr. Ron Zaneveld, OSU; Dr. Van Holliday, Tracor; Dr. Alice Alldredge and
Dr. Sally MacIntyre, UCSB.

An associated DURIP grant was funded by ONR for the acquisition of "In-water instrumentation for measurement of phytoplankton optical properties." This grant allowed me to purchase a SAFIRE and associated in-water instrumentation.

REFERENCES

Culver, M. E., and M. J. Perry. 1999. Fluorescence excitation estimates of photosynthetic absorption coefficients for phytoplankton and their response to irradiance. Limnology and Oceanography (in press).

http://www.ocean.washington.edu/people/faculty/perry/perry.html